NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

# IRRIGATION WATER CONVEYANCE
# STEEL PIPELINE

**(ft)**
**CODE 430FF**

## DEFINITION

A pipeline and appurtenances installed in an irrigation system.

## PURPOSE

To prevent erosion of loss of water quality or damage to land, to make possible the proper management of irrigation water, and to reduce water conveyance losses.

## CONDITIONS WHERE PRACTICE APPLIES

The pipeline shall be planned and located to serve as an integral part of an irrigation water distribution or conveyance system that has been designed to facilitate the conservation use of soil and water resources on a farm or group of farms.

All areas served by the pipeline shall be suitable for use as irrigated land.

Water supplies and irrigation deliveries to the area shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

## CRITERIA

Working pressure. The pipeline shall be designed to meet all service requirements without the use of a working pressure that will produce tensile stresses in the pipe greater than a design stress equal to 50 percent of yield-point stress. Design stresses for commonly used steel and steel pipe classes are shown in column two below:

| Specification and grade of steel | Design stress 50 pct yield point |
|---|---|
| | *lb/in.$^2$* |
| ASTM-A-283 | |
| Grade B | 13,500 |
| Grade C | 15,000 |
| Grade D | 16,500 |
| ASTM-A-570 | |
| Grade A | 12,500 |
| Grade B | 15,000 |
| Grade C | 16,500 |
| Grade D | 20,000 |
| Grade E | 21,000 |
| AWWA-C-200 | |
| Furnace butt weld | 12,500 |
| Grade A | 15,000 |
| Grade B | 17,500 |
| Grade X42 | 21,000 |

In computing tensile stresses in steel pipe, the following items must be considered:

1. The pressure to be delivered at the end of the pipeline.
2. The friction head loss,

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3. The elevation differential between the outlet and the inlet of the pipe, and
4. Any pressure due to water hammer or surge that may be created by the closure of a valve in the pipeline.

**Flow capacity.** The design capacity shall be based on whichever of the following is greater:

1. Capacity to deliver sufficient water to meet the weighted peak consumptive use rate of the crops to be grown, or
2. Capacity sufficient to provide an adequate irrigation stream for the methods of irrigation to be used.

**Minimum wall thickness.** Minimum pipe wall thickness shall be as follows:

| Nominal diameter | Wall thickness |
|---|---|
| *in.* | |
| 4 - 12 | 14 gage less 12.5 % |
| 14 - 18 | 12 gage less 12.5 % |
| 20 - 24 | 10 gage less 12.5 % |
| 26 - 36 | 3/16 in. less 12.5 % |
| 38 - 48 | 1/4 in. less 12.5 % |

**Friction loss.** For design purposes, the pipeline friction loss shall be based on that computed with Manning's Formula with n equal to no less than 0.012 for unlined and no less than 0.010 for lined pipe.

**Check, pressure-relief, vacuum-release, and air-release valves.** If detrimental backflow may occur, a check valve shall be installed between the pump discharge and the pipeline.

A pressure-relief valve shall be installed at the pump location if excessive pressure can build up when all valves are closed. Also, in closed systems where the line in protected from reversal of flow by a check valve and excessive surge pressure can build up, a surge chamber or a pressure-relief valve shall be installed close to the check valve on the side from the pump.

Pressure-relief valves shall be no smaller than ¼ in. nominal size for each diameter inch of the pipeline and shall be set at a maximum of 5 lb/in.$^2$ above the safe working pressure of the pipeline. A pressure-relief valve or surge chamber shall be installed at the end of the pipeline if needed to relieve surge.

Air-release and vacuum-release valves or combination air-release and vacuum-release valves shall be placed at all summits in the pipeline, at the end of the line, and between the pump and check valve if needed to provide a positive means of air entrance or escape.

Air-release and vacuum-release valve outlets shall be at least ½ in. in nominal diameter when specified for lines 4 in. or less in diameter, at least 1 in. outlets for lines 5 to 8 in. diameter, at lest 2 in. outlets for lines 10 to 16 in. diameter, at least in. outlets for lines 18 to 28 in. in diameter, at least 6 in. outlets for lines 30 to 36 in. in diameter, and at least 8 inches outlets for lines 38 to 48 in. in diameter.

For pipelines larger than 16 in. in diameter, e in. air-release valves may be used in place of the sizes indicated if they are supplemented with vacuum-release valves that provide a vacuum-release capacity equal to the sizes shown.

**Drainage and flushing.** Provisions shall be made for completely draining the pipeline if a hazard is imposed by freezing temperatures or if drainage is specified for the job.

If provisions for drainage are required, drainage outlets shall be located at all low places in the line. These outlets may drain at all low places in the line. If drainage cannot be provided by gravity, provisions shall be made to empty the line by pumping

**Outlets.** Appurtenances for delivering water from a pipe system to the land, to a ditch, or to a surface pipe system shall be known, as outlets. Outlets shall have capacity to deliver the required flow:

1. To a point at least 6 in. above the field surface,
2. To the hydraulic grade line of a pipe or ditch,
3. To an individual sprinkler, lateral line, or other sprinkler line at the design operating pressure of the sprinkler or line.

**Pipe supports.** Irrigation pipelines placed above ground shall be supported by suitably built concrete, steel, or timber saddles shaped to support the pipe throughout the arc of contact, which shall be not less than 90 degrees nor more than 120 degrees as measured at the central angle of the pipe. If needed to prevent overstressing, ring girder-type supports shall be used. Support spacing shall insure that neither the maximum beam stresses in the pipe span or the maximum stress at the saddle exceed the design stress values.

**Thrust control.** For aboveground pipelines with welded joints, anchor blocks and expansion joints shall installed at spacings that limit pipe movement due to expansion or contraction to a maximum of 40 percent of the sleeve length of the expansion coupling to be used. The maximum length of pipeline without expansion joints shall be 500 ft. Aboveground pipelines with rubber gasket-type joints shall have the movement of each pipe length restrained by steel hold-down straps at the pipe supports or by anchor blocks instead of normal pipe supports.

Anchor blocks usually are not required on buried pipelines. Expansion joints shall be installed, as needed, to limit stresses in the pipeline to the design values.

Thrust blocks shall be required on both buried and aboveground pipelines at all points of abrupt changes in grade, horizontal alignment, or reduction in size. The blocks must be of sufficient size to withstand the forces tending to move the pipe, including those of momentum and pressure, as well as forces due to expansion and contraction.

Abrupt changes in pipeline grade, horizontal alignment, or reduction in size require an anchor or thrust blocks to absorb any axial thrust of the pipeline.

Thrust blocks shall have a minimum thickness of six inches and a minimum height equal to the outside diameter of the pipe. The blocks shall fill the space between the pipe and the undisturbed earth at the side of the trench at bends and tees. Blocks at ends of lines shall bear against undisturbed earth or earth compacted at least to the density of the surrounding natural material. Blocks at ends of lines where the maximum working head exceeds 25 ft. shall be reinforced concrete.

The area of thrust block required is given by the following formula:

A = (98 HD2 / B) * sin (a / 2)Where:

H = Maximum working head in feet.
D = inside diameter of pipe in feet.
B = Allowable passive pressure of the soil in lbs per sq. ft. as follows:

in lbs per sq. ft. as follows:

Table 1.—Allowable soil bearing pressure

| Natural soil material | Depth of cover to center of thrust block 2 ft | 3 ft | 4 ft | 5 ft |
|---|---|---|---|---|
| | -----------------lb/ft2------------------------- | | | |
| Sound bedrock | 8,000 | 10,000 | 10,000 | 10,000 |
| Dense sand and gravel mixture (assumed Ø = 40º) | 1,200 | 1,800 | 2,400 | 3,000 |
| Dense fine to coarse sand (assumed Ø = 35º) | 800 | 1,200 | 1,650 | 2,100 |
| Silt and clay mixture (assumed Ø = 25º) | 500 | 700 | 950 | 1,200 |
| Soft clay and organic soils (assumed Ø = 10º) | 200 | 300 | 400 | 500 |

a = Deflection angle of pipe bend ( at ends of lines a = 180$^{o}$).

Anchors and thrust blocks shall be constructed of either:

1. Concrete poured to fill the space between the pipe and the undisturbed earth at the side of the trench on the outside of bends.
2. Soil cement with at least one part cement to 12 parts sandy loam or coarser texture soil, placed to fill the space between the pipe and the undisturbed earth at the side of the trench on the outside of bends and thoroughly tamped. The material shall be thoroughly mixed and tamped in a moist condition to set the cement.

**Joints and connections.** All connections shall be designed and constructed to withstand the working pressure of the line without leakage and to leave the inside of the pipeline free of any obstruction that would reduce the line capacity below design requirements. On sloping lines, expansion joints shall be placed adjacent to and downhill from anchors or thrust blocks. If cathodic protection is required, high resistance joints shall be bridged to insure continuous flow of current.

A dielectric connection shall be placed between the pump and the pipeline and between pipes with different coatings.

**Corrosion protection.** Interior protective coatings shall be provided if the pH of the water to be conveyed is 6.5 or lower. Cement mortar coatings may be used if the water to be conveyed has a pH of 5.5 or higher and a sulfate content of 150 ppm or less.

All pipe exteriors for underground lines must be fully protected against corrosion. To meet protection requirements, all pipe must be coated and must be provided with supplementary cathodic protection as specified in item 2 below:

1. A Class A protection coating shall be provided if the soil-resistivity survey shows that either (a) 20 percent or more of the total surface area of the pipeline will be in soil having a resistivity of 1,500 ohm-cm or less or (b) 10 percent or more of the total surface area of the pipeline will be in soil having a resistivity of 750 ohm-cm or less. A Class B coating shall be provided for pipe to be installed in soil having a resistivity greater than 1,500 ohm-cm.

2. Supplementary cathodic protection shall be provided if the soil-resistivity survey shows that any part of the pipeline will be in soil whose resistivity is less than 10,000 ohm-cm unless galvanized pipe is used. Pipe to soil potential shall be not less than is used. Pipe to soil potential shall be not less than 0.85 V negative,, referred to as a copper/copper-sulfate reference electrode, with the cathodic protection installed. The initial anode installation shall be sufficient to provide protection for a minimum of 15 years.

Cathodic protection shall be provided for galvanized pipe if the soil-resistivity survey shows that any part of the galvanized pipe will be in soil whose resistivity is less than 4,000 ohm-cm. Galvanized pipe requiring cathodic protection shall have a Class B coating.

The total current required, the kind and number of anodes needed, and the expected life of the protection may be estimated as shown below:

The total cathode current required may be estimated from the formula.

$$I_t = C\,[\,A_i / Re_1 + A_2 / Re_2 + \ldots A_n / R_{en}]$$

Where:

$I_t$ = total current requirement in mA
$A$ = surface area pipe in $ft^2$
$R_e$ = soil resistivity in ohm-cm
$C$ = a constant for a given pipe coating

For design purposes, this constant shall be considered to be not less than 32 for Class A coatings and not less than 60 for class B coatings.

The kind of galvanic anode to be used depends on the resistivity of the soils in the anode bed location. If the resistivity of the anode bed is:

a. Less than 2,000 ohm-cm, zinc anodes shall be used;
b. Between 2,000 and 3,000 ohm-cm, either zinc or magnesium anodes shall be used; and
c. Between 3,000 and 10,000 ohm-cm, magnesium anodes shall be used.

Anodes shall not be required on pipelines if soil resistivity is greater than 10,000 ohm-cm.

The number of anodes needed to protect the pipeline may be estimated by dividing the total cathode current requirement of the pipeline by the current output per anode.

Thus:

$$N = I_t / I_m \text{ and } I_m = k / R$$

Where:

$N$ = number of anodes needed
$I_t$ = total current requirement in mA
$I_m$ = maximum anode current output in mA
$k$ = constant for a given anode

R = soil resistivity of the anode bed in ohm-cm.

The expected life of an anode, based on the use of 17 lb / ampere year for magnesium and 26 lb / ampere year for zinc and a utilization factor of 0.80, shall be computed as follows:

Magnesium . . . . . $Y = 47W / I_o$

Zinc . . . . . . . . . . $Y = 31W / I_o$

Where:

$Y$ = expected life in years
$W$ = weight of anode in lb
$I_o$ = design anode current in mA = $I_m$ unless resistors are used in anode circuit to reduce output

If resistors are used to reduce anode current output to increase service life, the number of anodes required shall be based on the regulated output of the anode rather than on the maximum output, $I_m$.

3. Preliminary soil-resistivity measurements to determine coating requirements and the approximate amount of cathodic protection needed may be made before the trench is excavated. For this purpose, field resistivity measurements shall be made, or samples for laboratory analysis shall be taken at least every 400 ft. long the proposed pipeline and at points where there is a visible change in soil characteristics. If a reading differs markedly from a preceding one, additional measurements shall be taken to locate the point of change. Resistivity determinations shall be made at two or more depths in the soil profile at each sampling station; the lowest depth shall be the strata in which the pipe will be laid. The lowest valve of soil resistivity found at each sampling station shall be used as the design value for that station.

After the pipe trench is excavated, a detailed soil resistivity survey shall be made as a basis for final design of the coating and the required cathodic protection. At this time, resistivity measurements shall be made in each exposed soil horizon at intervals not exceeding 200 ft. The lowest value of soil resistivity found at each sampling station shall be used as the design value for that station. If design values for adjacent stations differ significantly, additional intermediate measurements shall be made.

Steel pipelines placed on the ground shall be limited to sites where the soil resistivity along any part of the pipeline is greater than 4,000 ohm-cm. Pipe at anchor or thrust blocks shall be embedded or attached rigidly with a hold-down strap.

All pipe installed above ground shall be galvanized or shall be protected with a suitable protective paint coating, including a primer coat and two or more final coating.

**Materials.** All materials shall meet or exceed the minimum requirements of this standard.

## CONSIDERATIONS

### Water Quantity

1. Effects on the water budget, especially on infiltration and evaporation.
2. Effects on downstream flows or aquifers that would affect other water uses or users.
3. Potential use for irrigation management.
4. Effects of installing a pipeline on vegetation that may have been located next to the original conveyance.

### Water Quality

1. Effects of installing the pipeline (replacing other types of conveyances) on channel erosion or the movement of sediment and soluble and sediment-attached substances carried by water.
2. Effects on the movement of dissolved substances into the soil and on percolation below the root zone or to ground water recharge.
3. Effects of controlled water delivery on the temperatures of water resources that could cause undesirable effects on aquatic and wildlife communities.
4. Effects on wetlands or water-related wildlife habitats.

5. Effects on the visual quality of water resources.

## PLANS AND SPECIFICATIONS

Plans and specifications for steel irrigation pipelines shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purposes.

## OPERATIONS AND MAINTENANCE

An operation and maintenance plan must be prepared for use by the owner or others responsible for operating the system. The plan should provide specific instructions for operating and maintaining the system to insure that it functions properly. It should also provide for periodic inspections and prompt repair or replacement of damaged components.